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(75) Inventors/Applicants (for US only): WEBB, Martin, John [GB/GB]; 4 Oasthouse Court, Saffron Walden, Essex CB10 1DX (GB). DAWSON, Frank, Thomas [GB/GB]; Woodside, Loughton Lane, Theydon Bois, Essex CM16 3JZ (GB).		With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
(74) Agent: KEITH W NASH & CO.; 90-92 Regent Street, Cambridge CB2 1DP (GB).		
(54) Title: IMPROVEMENTS IN AND RELATING TO SHEET MATERIAL INSPECTION APPARATUS AND METHODS		
(57) Abstract		
<p>A mounting for locating a detector (54) above a path (58) along which sheet material (30) passes at high speed comprises a thin elongate member (52) having a natural resilience, one end of which is attached to a fixed point above the path to extend therefrom in the direction of movement of sheet material along the path. Its other end (60) lightly contacts the upper surface of the path and therefore any sheet material moving therealong, and that end comprises a point of attachment for the detector (54). The natural resilience of the elongate member (30) maintains contact between it and the sheet material moving thereunder to flatten the sheet material and reduce any rippling effect introduced therein as it progresses along the path. However the natural resilience permits the elongate member to rise and fall due to any ripple or irregularity which has not been eliminated, and since the detector (54) is attached to the elongate member (52) it will also rise and fall with it, so that a substantially constant small gap can be maintained between it and the sheet material passing therebelow.</p>		

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Title: Improvements in and relating to sheet material inspection apparatus and methods

Field of invention

This invention concerns apparatus and methods for inspecting printed sheet material, and the invention is particularly applicable to inspecting sheet material on which bank notes, gift vouchers, postal orders, bank cheques, passports, labels for high value goods, lottery tickets and the like have been printed. Such items are generally referred to herein as security documents.

Background to the invention

Various techniques have been adopted to assist in validating security documents. One such technique involves the step of inserting during manufacture into a web of sheet material which is to be printed to form security documents, especially bank notes, a thin strip, or thread of material. The strip or thread is encoded with machine readable information as by a repetitive pattern of magnetisable regions along the length of the thread (as described in GB 2098768B). In the case of bank notes this thread can be seen by viewing the note in transmitted light although of course the magnetic regions remain concealed.

A continuous process is normally involved in the manufacture of a web of paper, and large rolls of paper containing such threads, accurately spaced apart across the width of the roll are produced. The subsequent web of paper is cut into sheets suitable for printing in a printing press. By accurately registering the sheets of paper in a printing machine, front and back faces of a security document such as a bank note can be printed on top and bottom surfaces of each sheet in correct

registry, not only with the sheet but also with the lines of thread, so that one thread extends across each resulting security document.

Since the printing plates employed in such processes are of finite size, the process for producing banknotes is arranged to print the sheets in a regular matrix or block containing 40 or so banknotes on each sheet. The sheets are stacked and can be inspected individually and either accepted as good or rejected as flawed before the sheets are guillotined into separate notes.

Historically the printing was checked by visual inspection of each sheet by specially trained staff. In recent years, using image analysis techniques, the print inspection process has been automated.

Whilst image analysis techniques permit the printing process to be checked, they do not allow the magnetic properties of the thread to be checked and validated. For example it is valuable to be able to check that it is continuous across each bank note impression, that the code is the correct code for the denomination of note under inspection, and/or that the code runs in the correct direction across the note, etc.

To this end a checking method has been proposed in which the sheet material containing the thread is moved relative to a magnetising device upstream of a high resolution magnetic field detector or reading head, from which electrical signals are derived as the magnetised thread passes below the reading head. The latter responds to the magnetic field associated with the residual magnetism in the magnetic regions of the thread after it has left the influence of the magnetising device. A checking device containing such a read head, and method as aforesaid is described in our co-pending UK Patent Application published under Serial No. 2316521, which contains details of the reading head and signal processing circuits required to

allow the proposed validation method for such magnetisable thread to be performed. Where a magnetisable thread is included in sheet material from which other security documents are formed, a similar procedure can be adopted as described above for bank notes. A read head, especially one containing a magneto-resistive sensor, is described in UK No. 2316521 and will be referred to as a "read head of the type described".

The present invention has particular relevance to the checking of a magnetisable thread extending through cut sheets of paper on which blocks of security documents have been printed, after the sheets have been print checked and before being guillotined into separate documents.

Object of the invention

It is a primary object of the invention to provide an improved method of and apparatus for checking and validating the properties of magnetisable threads incorporated in security documents.

It is another object to enable such checking to be performed without interrupting the production process.

It is a further object to enable the checking to occur in such a way and at such a point in the process as to allow flawed material and the type of flaw to be identified, and for the flawed material to be discarded with minimal interruption to the production process.

Summary of the invention

According to the present invention, there is provided a method of checking or validating the properties of an elongate magnetisable element contained in or on sheet material containing printed matter defining a security document comprising the steps of, subjecting the sheet material to a

magnetic field to magnetise the magnetic regions of the element therein, producing relative movement between the sheet material and the magnetic field, at a point remote from the influence of the magnetising field sensing any residual magnetism in the element by a read head comprising a high resolution magnetic field detector, generating electrical signals indicative of any residual magnetism detected, processing the electrical signals so produced to determine if the residual magnetic pattern producing them is correct for the document through which it extends, generating a warning signal if the signal processing indicates that the magnetic pattern is incorrect or incomplete or non-existent, generating a routing signal in response to a warning signal and operating a sheet diverter to change the destination to which the printed sheet is to pass after the magnetic check, from a first destination reserved for the sheets which have passed the magnetic check to an alternative destination for sheets which have failed the check.

The signal processing may provide signals indicative of the types of flaw detected in the parameter under test, such as the security thread in the case of banknotes.

The method may comprise the step of marking any sheet identified as containing a flaw, such as a flaw in the security thread in the case of a banknote.

The method may also involve the step of diverting flawed sheets to different destinations depending on the type of the flaw in the security parameter being checked.

The invention also lies in apparatus for performing any of the above methods.

Illustrated example

The invention will now be described by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic side elevation of apparatus in accordance with the invention for checking printed sheets of bank notes, fitted with a magnetic field detecting read head of the type described, for checking the validity of magnetisable thread in the sheets; and

Figure 2 is an enlarged side view of part of the apparatus shown in Figure 1.

Detailed description of the drawings

In Figure 1 the apparatus comprises an elongate housing 10 within which is mounted a drive motor 12 for a conveyor 14 which passes around rollers such as 16, 18 and over rollers such as 20. Below longer horizontal upper runs of the conveyor are located suction boxes such as 22, 24, 26 and 28 and the conveyor is perforated so that printed sheets of bank notes are held down in contact with the conveyor as they are moved thereby.

A stack of printed sheets awaiting checking is shown at 30 carried in a tray 32, and a sheet feeder (not shown) lifts the sheets from the top of the stack one by one and places them on the conveyor 14 where it extends between rollers 34 and 16. A further suction box 36 is located below this run of the conveyor to hold the sheets into contact with the conveyor.

A housing 38 comprising an inspection station and containing one or more high resolution television cameras (not shown) and signal processing circuit means (not shown) and a computer based control system (not shown), extends across the machine housing 10 above and below the run of the conveyor between rollers 16 and 20, and illumination means is provided (not shown) to enable images of the printed sheets to be formed in the cameras. The signal processing circuit means provide signals indicative of the imaged areas of printing and logic and/or signal processing circuits determine from pre-loaded

data if the printed areas are flawed. The computer-based control system generates destination routing signals in synchronism with the conveyor movement so as to route each inspected sheet to one of three hoppers 40, 42 and 44. The routing signals are determined from the decision made by the logic and/or processing circuits as to whether any of the inspected printing on the sheet is flawed or not.

Sheets whose printed images pass the test applied by the control system to the processed camera signals, are routed to hopper 40 by momentarily rotating a conveyor section 46 from a horizontal position into a downwardly inclined position by operating a motor 47, to deliver such sheets to the hopper 40.

If the sheet fails the camera check, the control system instead delivers the sheet to hopper 42 by rotating conveyor section 48 into a delivery mode by driving motor 49 instead of 47, at the appropriate time.

Each conveyor section 46, 48 etc is returned to its upper position as soon as it has delivered a sheet to its associated hopper. This allows sheets to pass over the lowerable conveyor sections such as 46, 48 etc to reach a later lowerable conveyor section if the routing signal requires the sheets to pass by hopper 40 (or 42) etc.

Beyond the camera inspection part of the machine, a bridge 50 spans the width of the machine and so extends across the conveyor 14. A plurality of springy metal strips, one of which is shown at 52, are attached to regularly spaced apart points across the bridge 50.

Each strip 52 is bent upwardly at both ends, the bend at the left hand end 60 having a sharp right angle to provide a mounting surface to which a high resolution magnetic field detecting read head 54 of the type described is attached. The bend at the other end (the right hand end as shown) is rather

more gradual, but nevertheless continues until the metal strip is generally vertical, to enable it to be secured to the bridge 50.

The radius of curvature at the right hand end is greater than that at the left hand end to produce a smooth gently curved underside, and this smooth curved underside defines with the generally flat conveyor 14 a mouth 56 that converges in the direction of movement of the conveyor, and also therefore the movement of the sheets of bank notes, as denoted by arrow 58 in Figures 1 and 2.

As better seen in Figure 2, magnetic field detecting read head 54 is mounted to the upwardly bent left hand end 60 of the strip 52, and lightweight cables 62 and 66 connect the output 64 of the read head 54 to the signal processing circuit means and control system in the housing 38.

The control system generates a further routing signal if the magnetic detector signals denote an invalid, damaged or non-existent magnetisable thread (known as IMT), so as to drop the third conveyor section 68 (by means of drive 69) and deliver the sheet to hopper 44, instead of hopper 40 or 42.

After a run of sheets, the three hoppers 40, 42 and 44 will have between them all the sheets which have been checked, those in 40 having passed both camera and thread inspections, those in 42 having failed the camera inspection test, and those in hopper 44 having failed the thread check by read head 54.

As described, sheets which fail both camera and thread checks will be routed to hopper 42 as well as those which have failed only the camera check. A fourth hopper (not shown) may be provided if desired, and logic circuits provided to generate a countermanding signal to nullify the operation of the motor 49 if a sheet has failed both tests, so as to route such sheets to the fourth hopper (not shown) instead.

Where each sheet contains for example eight rows and five columns of bank note impressions, so that each row contains five bank notes, and each bank note contains a magnetisable thread, five metal strips 52 are provided, spaced apart across the bridge 50, so that each strip registers with the position of a magnetisable thread in one of the five columns of bank notes.

However the invention is not limited to the provision of only just the number of strips corresponding to the number of read heads, and purely for flattening purposes additional metal strips may be mounted between and beyond those carrying the read heads. The additional strips do not need to have the upturns at their downstream free ends.

Where timing pulses are needed for the circuits associated with the read head, these may be obtained from the conveyor 14 or from a sensor set to monitor movement of the sheets under inspection so as to provide synchronising pulses and timing pulses indicative of the approach of sheets to the read head, and the speed of movement of a sheet past the head. A shaft encoder can be used to indicate speed of the conveyor and therefore the relative speed between the sheets and the read head.

A device similar to item 52 could be mounted on a machine adapted to handle a continuous web of material.

CLAIMS

1. A method of checking or validating the properties of an elongate magnetisable element contained in or on sheet material containing printed matter defining a security document comprising the steps of, subjecting the sheet material to a magnetic field to magnetise the magnetic regions of the element therein, producing relative movement between the sheet material and the magnetic field, at a point remote from the influence of the magnetising field sensing any residual magnetism in the element by a read head comprising a high resolution magnetic field detector, generating electrical signals indicative of any residual magnetism detected, processing the electrical signals so produced to determine if the residual magnetic pattern producing them is correct for the document through which it extends, generating a warning signal if the signal processing indicates that the magnetic pattern is incorrect or incomplete or non-existent, generating a routing signal in response to a warning signal and operating a sheet diverter to change the destination to which the printed sheet is to pass after the magnetic check, from a first destination reserved for the sheets which have passed the magnetic check to an alternative destination for sheets which have failed the check.
2. A method as claimed in claim 1, wherein the signal processing step also generates signals indicative of the type of flaw detected in the security parameter being checked.
3. A method as claimed in claim 1 of claim 2, further comprising the step of marking any sheet identified as containing a flaw.
4. A method as claimed in claim 2 or claim 3, further comprising the step of diverting flawed sheets to different destinations depending on the type of flaw in the security

parameter being checked.

5. Apparatus for performing the method of any one claims 1 to 4.

6. Apparatus for and methods of checking or validating the properties of an elongate magnetisable element defining a security document substantially as herein described with reference to, and as illustrated in, the accompanying drawings.

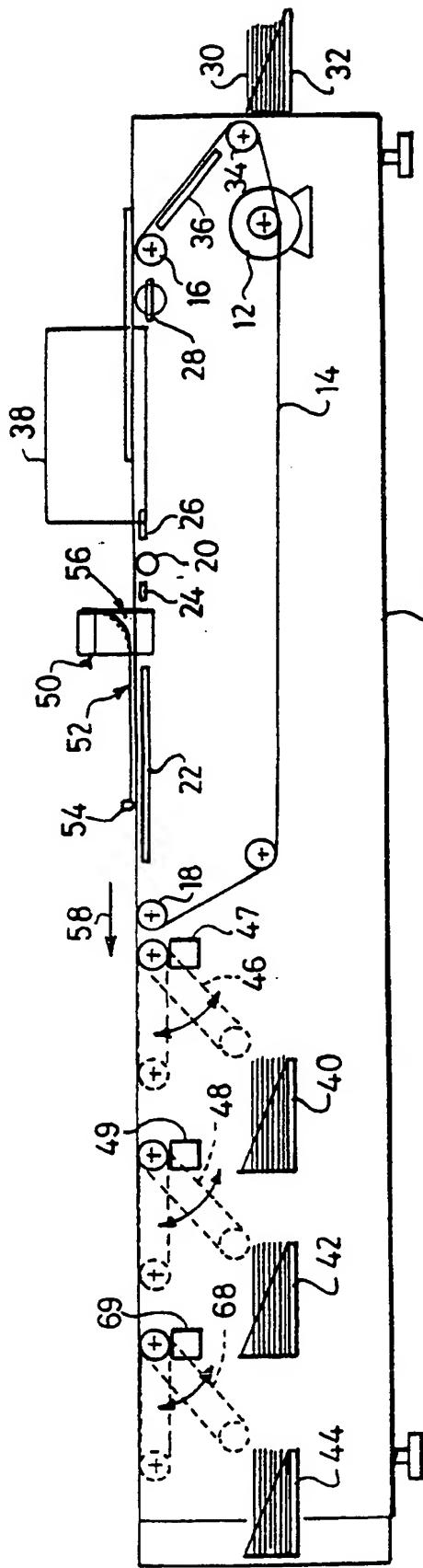


Fig. 1

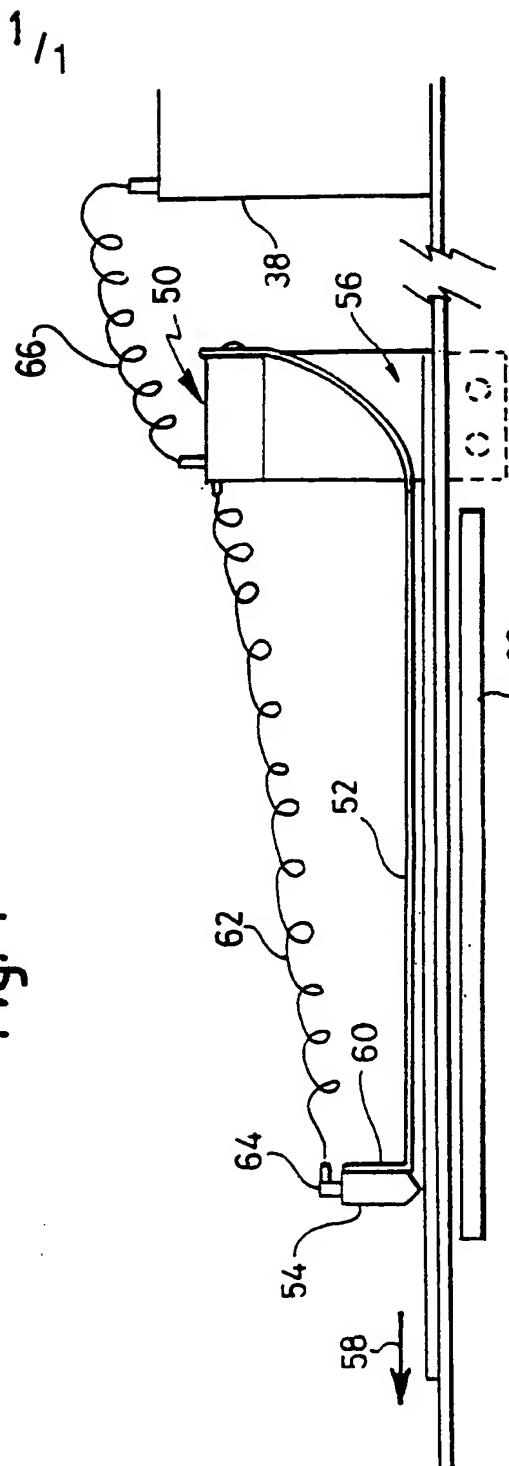


Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/GB 99/02662

A. CLASSIFICATION OF SUBJECT MATTER

G06K7/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06K, G06F, B42D, G07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 4427000 A (AZKOYEN INDUSTRIAL S.A.) 09 February 1995, claim 1, fig. 1. --	1, 5, 6
A	US 5599047 A (KAULE ET AL.) 04 February 1997, claim 1, fig. 1. --	1
A	US 5354099 A (KAULE ET AL.) 11 October 1994, claim 1, fig. 1. --	1
A	US 4806740 A (GOLD ET AL.) 21 February 1989, claims 1,13,17, fig. 1-5.	1, 5, 6



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search
10 November 1999

Date of mailing of the international search report

27.12.1999

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INTERNATIONAL SEARCH REPORT

International Application No
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-2-

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0268450 A (LIGHT SIGNATURES, INC.) 25 May 1988, abstract, fig. 1. --	1
A	US 5341408 A (MELCHER ET AL.) 23 August 1994, abstract, fig. 1-4. ----	1

ANHANG

zum internationalen Recherchenbericht über die internationale Patentanmeldung Nr.

ANNEX

to the International Search Report to the International Patent Application No.

PCT/GB 99/02662 SAE 245457

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten internationalen Recherchenbericht angeführten Patentdokumente angegeben. Diese Angaben dienen nur zur Orientierung und erfolgen ohne Gewähr.

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The Office is in no way liable for these particulars which are given merely for the purpose of information.

ANNEXE

au rapport de recherche international relatif à la demande de brevet international n°

La présente annexe indique les membres de la famille de brevets relatifs aux documents de brevets cités dans le rapport de recherche international visée ci-dessus. Les renseignements fournis sont donnés à titre indicatif et n'engagent pas la responsabilité de l'Office.

Im Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche		Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication	
DE A1	4427000		ES UA ES YA	1024937 1024937	
US A	5599047	04-02-1997	US A US A AT E BR A CA AA CA C DE A1 DE CO DK T3 EP A1 EP B1 EP T3 EP T3 FI A FI AO FI B1 GBR T3 NO AO NO A PL B1 PL B1 PT A WO A1	5354099 5803503 143871 9106119 2076532 2076532 4041025 59108270 516790 516790 2092090 923700 923700 102879 3021431 923258 923258 168961 168961 9210004 9211142	11-10-1994 08-09-1998 15-10-1994 02-03-1993 21-06-1993 08-15-1998 25-06-1992 14-11-1996 17-03-1997 09-12-1992 09-10-1996 16-11-1992 18-08-1993 18-08-1993 15-03-1995 31-01-1997 19-08-1992 19-10-1992 31-05-1996 30-08-1996 28-02-1996 09-07-1992
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